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Seasonal Bed Sediment Characteristics of the Kuala Sepetang River, Perak
(Ciri-ciri Sediment Dasar Mengikut Musim di Kuala Sungai Sepetang, Perak)

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ABSTRACT

Bottom sediment samples from the Kuala Sepetang River, Taiping, Perak were analysed for the grain size in order to understand better the sedimentation processes in the estuary and along the river. The mean, standard deviation and skewness value of each sample were calculated by the moment's method where each of every grain plot data was used to obtain the statistical information concerning the sedimentary population. In this study, there is no significant ($p<0.05$) *relationship between sediment characteristic with the seasonal changes, but the mean particle size became a relatively smaller size during the monsoon season. Finer sediments (7.4 ∅) were dominated during monsoon season while coarser sediments (6.2 ∅) dominated during the dry season. The characteristics of deposited sediments at each station are much dependent upon the combination of physical forces such as freshwater runoff, tidal currents and waves.*

Keywords: Kuala Sepetang River; grain size; sediment characteristic; monsoon season

ABSTRAK

Sampel sedimen dasar dari Kuala Sungai Sepetang, Taiping, Perak dianalisis bentuk butiran saiz bagi memahami dengan jelas proses sedimentasi di muara dan sepanjang sungai. Nilai min, sisihan piawai dan kepencongan bagi setiap sampel diukur dengan kaedah momen dengan setiap butiran data digunakan bagi memperolehi maklumat statistik yang berkaitan dengan populasi sedimen. Tiada hubungan yang signifikan ($p<0.05$) *di antara ciri-ciri sedimen dengan perubahan musim, cuma nilai min saiz partikel yang menunjukkan penurunan secara relatif pada kedua-dua musim. Sedimen yang lebih halus (7.4 ∅) mendominasi sungai semasa musim monson manakala sedimen yang lebih kasar (6.2 ∅) mendominasikan sungai pada musim bukan monson. Ciri-ciri pemendakan sedimen bagi setiap stesen banyak bergantung kepada gabungan faktor fizikal seperti aliran air tawar, arus pasang surut dan ombak.*

Kata kunci: Kuala Sungai Sepetang; saiz butiran; ciri-ciri sediment; musim monsoon

INTRODUCTION

Estuarine areas where freshwater encounters seawater are characterized by a lateral variation in salinity. It can represent as a transfer box for the sediments between land and the open ocean (Morris 1990). They are dynamic areas where a huge amount of organic matter and trace metals meet the ocean system through river flow, *in situ* primary production and anthropogenic impacts (Agrawal & Pottsmith 2000). Bed sediments vary significantly in composition, shape, size and respond differently to the movement of water, where the bed particles size will reflect local water dynamics and exerts a control on benthic organism. Range of sizes will determine the packing of the sediment particles and the availability of pore spaces, when interstitial fluids may pass through. Particle size is an important textual parameter to determine the transportation, sorting and deposition processes of bed sediment. In addition, determination of particle size provides information about history events occurred at the prior depositional site to final indurations (Agrawal & Pottsmith 2000). It has been well established that estuaries trap particles and some dissolved materials transported in rivers (Kamaruzzaman 1994; Kennedy 1984). Consequently, estuarine sediments are considered to be important sinks for nutrients, organic matter, trace substances and contaminants derived from inland sources (Burton 1988; Goldstein & Jacobsen 1988). In riverine, estuaries, as freshwater mixes with seawater, material transport and deposition can be affected by river flow, tidal flow, wave activity, currents and non-tidal circulation patterns (Dyer 1979). According to Visser (1996), sediment mean size which are lower than 3.5 ∅ will travel as bed load, while the sediment with mean size which is higher than 3.5 ∅ will travel as suspension loads. The coarsest sediment, consisting of sand, moves on or near the bed of the river and categorised as the riverbed load. The finer particles, silt and clays are carried in suspension by the turbulent action of flowing water, which are moved long distance at the velocity of the flowing water, constitute the suspended load of the river.

In Malaysia, even though studies relating physico-chemical and biology aspects of the main river are well documented (Kamaruzzaman 1994; Kamaruzzaman et al. 2002), studies on bottom sedimentation are quite limited. However, other sediment surrogate measurement techniques including those based on acoustic backscatter, remote sensing and digital photo-optic are many done by the local agencies like Malaysian Institute for Nuclear Technology, Department of Irrigation and drainage and local universities. Nevertheless, detailed investigation concerning both spatial and temporal variability is required in order to better understand the sedimentation processes in the estuaries and along the Sepetang River. In view of the importance of the bottom sedimentation data to various aspects of the environment, research on the seasonal bottom sediment characteristics of the Kuala Sepetang River as well as their distribution pattern was carried out.

METHODOLOGY

Kuala Sepetang is located in the Taiping district that is situated near the Taiping town (4° 51'N, 100° 44'E). The sea water intruded up to the furthest station (sation 1), approximately 15 km away from the estuary. The study area lies in the wet tropics where high rainfall was recorded during the wet season in October and ends in April. Taiping district have highest rainfall with mean rainfall of 4119 mm per year. Sampling were carried out twice, first sampling during dry season (May 1993) and secondly during rainy season (January 1993). A total of 15 stations (Figure 1) were collected during both sampling period using the ekman grab in the middle of the river. Bottom sediment from the ekman grab (2 cm depth) was collected at each station. In this study, 3 samples were collected across the mouth of estuary and 12 samples were collected at 1 km interval inside the Sepetang Rivers commencing from the mouth of the rivers (Figure 1).

Sediments were oven dried at 105 °C for 24 hours and powdered prior to analysis. From the preanalysing using dry and wet method (Folk 1974), samples which consists of more than 90% sand were analyzed using the dry sieving method, while samples having more than 90% fine sediments were analysed using the laser diffraction method. Sedimentological characteristics were reported in phi (∅) units using the conversion factor of Folk (1974) as stated below. By using the negative value, coarse grain size will have a lower phi (∅) value which tend to increase when the particles size become finer.

$$\varnothing = -\log_2 D \qquad (1)$$

where D is the diameter of the particle in mm.

The mean, standard deviation and skewness of each sample were calculated by the moment's method using equations defined by McBride (1971). The moment's method uses data from every grain plot data to obtain statistical information concerning the sedimentary population. The formula proposed by McBride (1971) was used to calculate the sedimentological characteristics of mean, skewness and sorting are as follows:

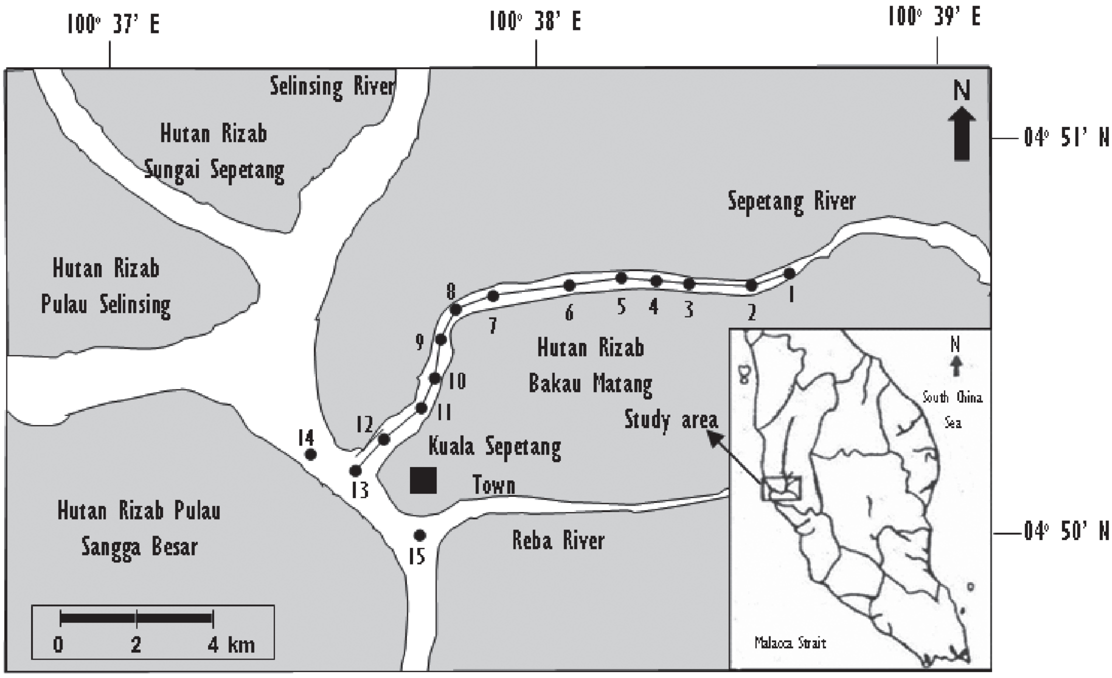

FIGURE 1. Location of study area showing the sampling site along Sepetang River, Taiping, Malaysia

$$X_\phi = \frac{\sum fm}{n}. \quad (2)$$

$$\sigma_\phi = \frac{\sum f\left(m - X_\phi\right)^2}{100}. \quad (3)$$

$$Sk_\phi = \frac{\sum f\left(m - X_\phi\right)^3}{100\,\sigma^3}. \quad (4)$$

where X_ϕ is the mean size, σ_ϕ is the sorting, Sk_ϕ is the skewness, f is the weight % or volume % (frequency) of each size class, n is the number of sample, m is the mid-point of each size class.

Silt and clay content of the bottom sediment were analyzed using a laser diffraction method. The laser diffraction method is based on the principle of laser ensemble light scattering. The 45 mm focus lens is used to detect the fine particles with sizes ranging between 0.1 μm and 80 μm. Briefly, samples were prepared by first dissolving all carbonates using 4M hydrochloric acid solution. Then the organic components were removed by adding 20 % hydrogen peroxide (H_2O_2) solution and finally with calgon solution to break up of flocs that may have formed with clays. The solution was then stirred, and measured using the subjected to ultrasonic bursts of 10 to 15 seconds duration, before being poured into the Partical Size Analyzer (PSA) system. Percentages of clay, silt and sand were then calculated to determine the texture of sediment using the classification standard proposed by Nichol et al. (1967).

RESULT AND DISCUSSION

SILT AND CLAY CONTENT

The percentage of silt and clay of the bottom sediment in Sepetang River were registered more than 80% at all stations and the silt and clay content do not show a significant difference between both seasons but only showing a lower relatively content towards the estuary. This indicates that the particle transport in the study area is mainly influenced by river discharge that flows to the estuary. The bottom sediments for both seasons consist of sand ranged from 3.5% - 10.2%, silt from 45.5% – 63.2% and clay from 26.6% – 51.7% (Figure 2). The distribution patterns of percentage of sand, silt and clay in the estuary (stations 1, 2 and 3) dominating a very medium silt grained while the texture near the estuary (stations 13, 14 and 15) were much bigger with a coarser silt grained. Eventhough, the transportation of suspended and bed load material in estuaries are complicated, the scenario observed in this study indicates that the swift river flow will allow little fine sediment to deposit but this flow is reduced drastically upon reaching the larger estuary, thus allowing more fine sediment to be deposited. However, it is difficult to

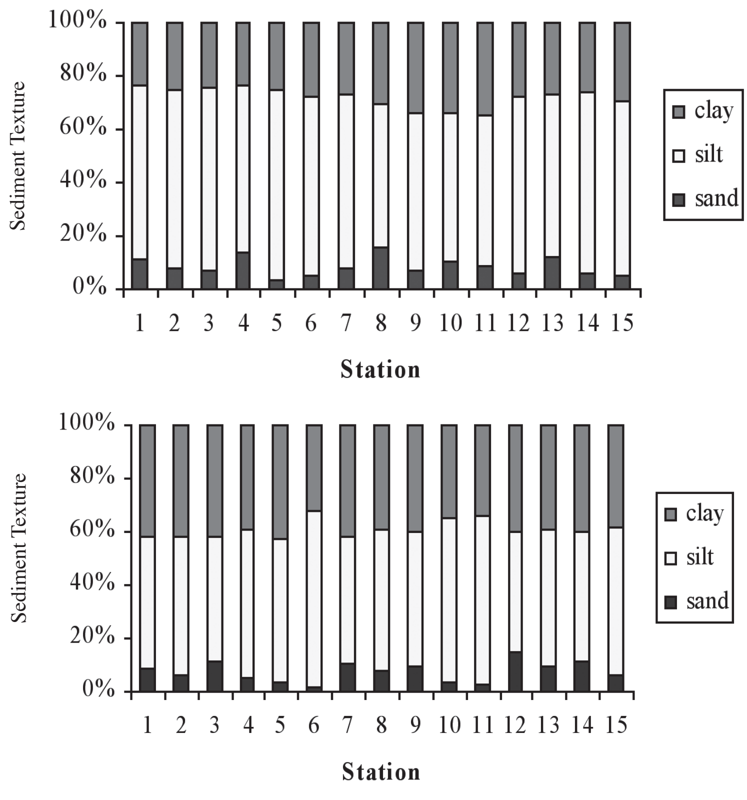

FIGURE 2. Texture percentage of sand, silt and clay during (a) dry season and (b) wet season

distinguish the sediment deposit from the suspended load as one stage of the tidal cycle; the sediment deposited in the river bed may be resuspended at another tidal stage. Secondly, the tides play a significant role in transporting sediments offshore into the estuary, thus the offshore materials consisting of mostly fine sediments would also be transported into the estuary but only little would reach further upstream due to the opposing river currents (Kamaruzzaman et al. 2003).

MEAN (X_ϕ)

Mean is an index of grain size measurement due to its weight. The obtainable of mean values could determine the size of sediment grain. The increasing mean value indicates the decreasing of grain sizes and vice versa. The mean size gives a good indication of the magnitude of the force, applied by water which will transport the grains. The mean value along the Sepetang River ranged from 6.2∅ to 7.4 ∅ or ranging from the coarse silt to medium silt. The estuary area (stations 1, 2 and 3) and some station near the estuary (stations 4, 5 and 6) are dominated by coarser silt, meanwhile the sampling station that are far from estuary (stations 7 – 14) are more dominated by the medium silt texture. This can be explained by the high water velocity from the river flow which transport the fine sand and left the coarser sand on the river bed. The large amounts of suspended and fine sand were transported to the estuary, trapped and settle down during tidal.

STANDARD DEVIATION (S_ϕ)

Standard deviation referred to as sorting and indicates the range of forces which determined the sediment size distribution (Briggs 1977; Dyer 1985). A large value of standard deviation (a poor sorted) indicates that little selection of grain had taken place during transportation deposition. Good sorting, indicated by a small standard deviation, on the other hand is produced by the selective action of energy which transport and deposit limited range of grain size. In this study, sorting do not show a significant difference between monsoons and these were proven by correlating between the mean sizes and sorting (Figure 3). Sorting has ranged values 1.4 ÿ to 2.23 ÿ, indicating that the sediments in general are poorly sorted to a very poorly sorted. A moderately sorting (–0.65 ÿ) were observed at stations 2, 8 and 11 and these can be explained by their geographical position of the river with a slope curve which reduce the water flow and allowing more selection of grain to deposited.

SKEWNESS (Sk_ϕ)

Skewness is the measure of the degree of symmetry to provide a measure of the tendency of the data to spread preferentially to one side of the average value. The symmetrical distribution indicated the different sizes of sediments are similarly distributed. A positive skewness indicates an excess of fine grain sizes which could be due either to the addition of fine sediment to the deposits or to the selective removal of the coarser grain. In this study, skewness in the Sepetang River also showed insignificant between monsoons ($p > 0.05$) and has a wide range from –0.65 to 0.24 which falls from a moderated sorted to a poorly sorted type. In general, the negative skewness was observed at the station near the estuary (stations 13, 14 and 15) while the positive skewness were shown at the station away from the estuary.

CONCLUSION

The sediment characteristics in the study areas are not much influenced by the monsoons. However, the mean particle size became a relatively smaller size during the monsoon season. Finer sediments (7.4 ∅) were dominated during monsoon season while coarser sediments (6.2 ∅) dominated during the dry season. The characteristics of deposited sediments at each station are probably dependent upon the combination of physical forces such as freshwater runoff, tidal currents and waves, even though those physical combinations were not discussed in this study.

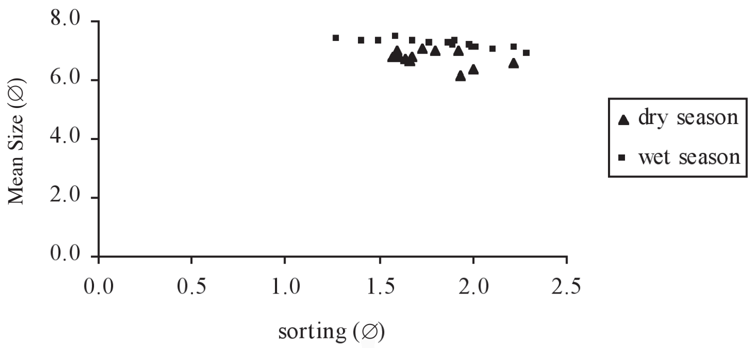

FIGURE 3. Correlation of mean size against sorting, showing the smaller size of sediment dominating during monsoon

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